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TEMPERATURE REGIME OF LOW-HEAD EARTH DAMS IN CENTRAL YAKUTIA (T--ETC(U)
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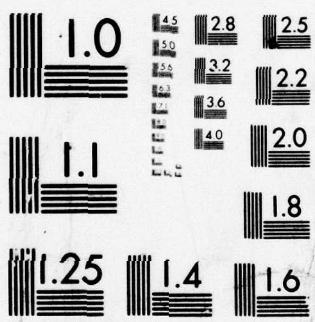
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TEMPERATURE REGIME OF LOW-HEAD EARTH DAMS IN CENTRAL YAKUTIA

D.N. Sleptsov

CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
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The temperature regime of dams on permafrost foundations is one of the basic factors which insures normal functioning of the structure. The dams of the catchwork irrigation systems for meadows and water supply under conditions of Central Yakutia generally have heads of 3-5 meters. This report investigates the temperature regime of such dams. Temperature influences of the banks of the valley and heat from the earth's interior are investigated. Thermal engineering calculation of the extreme temperature state and time of reaching

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the extreme temperature state of the body of the dam are also explored.

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TEMPERATURE REGIME OF LOW-HEAD EARTH DAMS IN CENTRAL YAKUTIA

Yakutsk TRUDY YAKUTSKOGO NAUCHNO-ISSLEDOVATEL'SKOGO INSTITUTA SEL'SKOGO KHOZYAYSTVA in Russian No 12, 1972 pp 87-92

[Article by D. N. Sleptsov, Yakutsk division of the East Siberian State Planning, Surveying, and Scientific Research Institute of Water Management Construction]

[Text] The temperature regime of dams on permafrost foundations is one of the basic factors which insures normal functioning of the structure.

The dams of the catchwork irrigation systems for meadows and water supply under conditions of Central Yakutia generally have heads of 3-5 meters. They are, in other words, low-head dams and, in most cases, are built of local earth material.

Investigation of the temperature regime of such dams is important for both theory and practice. There is practical interest in:

a. thermal engineering calculation of the extreme temperature state;

b. time of reaching the extreme temperature state and time of occurrence of complete freezing of the body of the dam;

c. thermal influence of the temporary reservoir on the temperature regime of catchwork irrigation dams;

d. an estimate of the temperature influences of the banks of the valley (spatial conditions) and heat from the earth's interior.

As the dams are operated over a period of time there arrives a more stable distribution of temperature in the body and foundation; this is called the extreme temperature state. According to calculations, this state is reached in the body of dams under average conditions for Central Yakutia in the first 7-10 years of use (see Figure 1). During this time

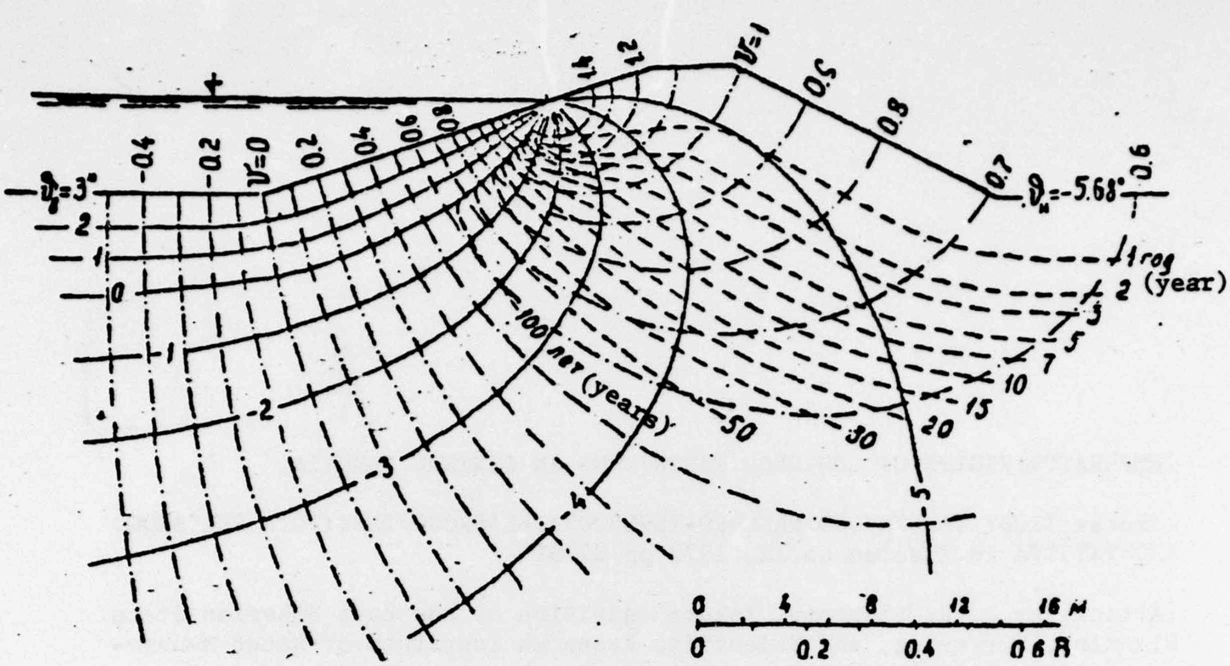

Figure 1. Time of Reaching a Permanent Temperature State in Low-Head Dams for the Case Where B /H = 4.2. Cross-section on the Plane of Symmetry of the Valley (calculation by streamtubes, time in years)

—— contour of the dam and isotherm V;

—·— axial line of streamtube V;

— — arrival of permanent state in years;

B -- breadth of reservoir; H -- height of the dam;

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more stable boundaries form between the zones of permanently thawed and permanently frozen ground and the zone of alternating thawing and freezing (see Figure 2). The calculation was made by the analytic graph method according to streamtubes for a permanent thermal field, taking account of spatial temperature conditions. In the particular case the dam considered had a height of six meters with a head of 4.5 meters, an upstream slope of 1:3, and a downstream slope of 1:2. The length along the crest was 30 meters. The configuration of the ground zones with diverse aggregate states of moisture in the interstices agrees well with the data from on-site observations at Lake Dolgoye in Noril'sk by G. N. Maksimov (Boguslovskiy, 1969).

Some data from on-site investigations by the author are given below.

Observations of change in the temperatur regime of the temporary storage dam on the Suon Uryakh River at the Pokrovskoye Experimental Model Farm show that an earth dam six meters in height composed of thawed sandy loam ground, under natural conditions with no subchannel talik (tabetisol), froze during the first winter after being built (see Figure 3). The dam has an open-type shoreward spillway with flat gates.

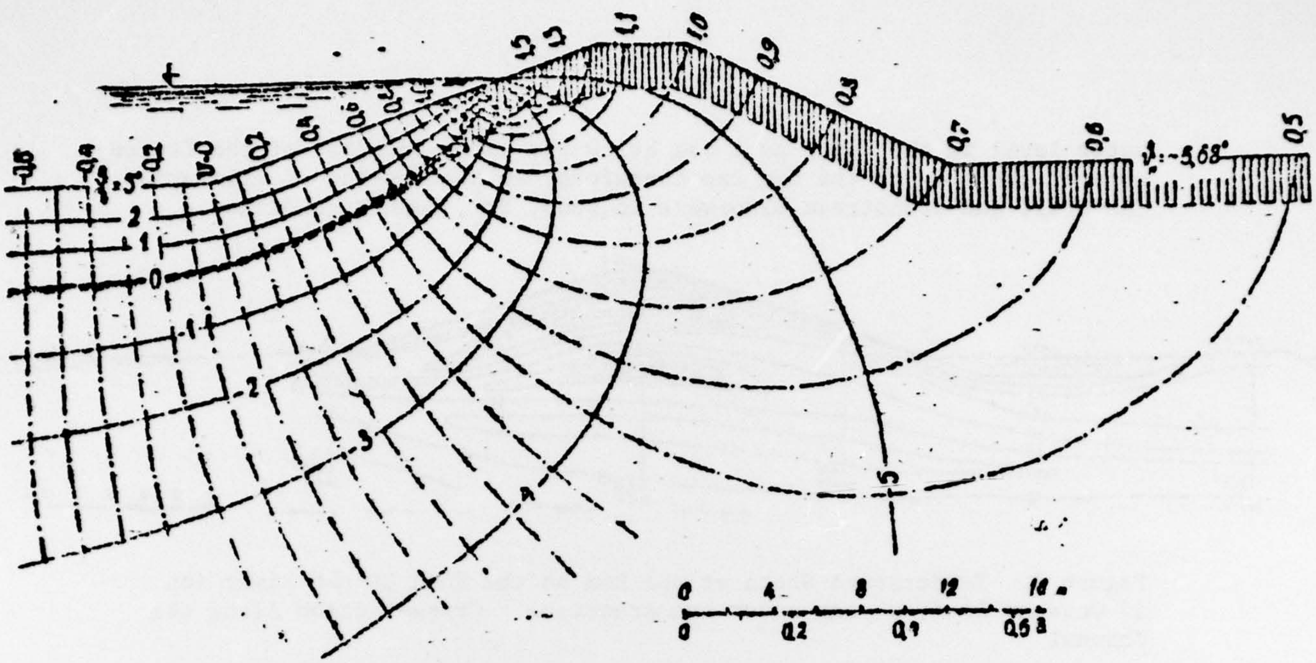

Figure 2. Zones of Different Ground States of the Body and Foundation of the Dam

- ——— contour of the dam and isotherm;
- —·— axial line of the streamtube;
- — — — boundary of the zone of different aggregate states of the ground;
- zone of alternately thawed and frozen ground;
- · · · points plotted by data from calculations.

Observations were made of two fixed constant-head dams with automatic spillways in natural gullies of the stream's floodplain. Both dams were built in August 1958 on the Tatta River in Churapchinskiy Rayon using thawed loamy ground. There are no subchannel taliks beneath the foundations of the dams; they are composed of icy silt ground. Sounding was done on 27 August 1961 (three years later).

The first dam was built at the mouth of the Khondu River (a right-bank tributary of the Tatta) and has a height of 4.5 meters with 3.5 meters of water in the upper pool and 1.4 meters in the lower pool. The dam received full head quickly after it was poured as the result of rains. The body showed strong filtration and so additional ground was poured on the lower pool side. At the moment of investigation this filtering thawed dam was completely frozen, without any special influences. At the moment of investigation water from the upper pool was filtering above the frozen part of the body to the downstream slope, [which] was in a viscous state.

The second dam was built at the mouth of the Babata River (a right-bank tributary of the Tatta); it has a height of 4.7 meters with a water depth of 2.5 and with a dry lower pool. The head was created by the 1959 floods. At the moment of investigation the dam was also completely frozen. The

water level in the upper pool was below the upper boundary of the frozen zone of the body of the dam and therefore, in the absence of filtration, the crest and downstream slope were in good, dry, sodded condition.

Figure 3. Temperature State of the Dam on the Suon Uryakh River (on 27 October 1965, a year after construction). Cross-section Along the Channel

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Observation data of the depth of seasonal thawing of the body of an earth dam with a fill crest are of some interest. Observations of the temperature regimes of the three dams discussed above show that in open, well-warmed conditions loamy ground fill of average humidity thaws to 1.8 meters (on the Tatta River) and fill of relatively dry sandy loam ground (on the Suon Uryakh River) thaws to 2.6 meters deep in the warm season. These figures agree well with our calculations.

Concerning the thermal effect of a temporary reservoir (in catchwork irrigation for a period of up to one month) it should be noted, on the basis of observation data for the dam on the Suon Uryakh River, that spring melt waters in the temporary reservoir do not have a significant thermal effect on the temperature regime of the body of the dam. The water head held steady before the dam for 20 days.

On the basis of this research we would like to observe that it is wise when calculating the extreme temperature state of dams to take account of the cooling effect of the banks of the stream when the breadth of the reservoir is less than 10 times the height of the dam. The direction from the middle of the dam to the banks of the valley will have a substantial cooling effect (Sleptsov, 1970). Consideration of this circumstance will enable us to freeze a dam more rationally and select more economical cross-sectional dimensions for a dam. Furthermore, when calculating the extreme temperature state of a dam consideration should be given to the warming effect of the heat from the earth's interior when the breadth of the permanent pool before the dam is more than one fourth of the depth of the earth's crust from the ground surface where a positive temperature deeper than the lower boundary of the permafrost zone will be equal to the temperature of the bottom of the reservoir.

To generalize for the conditions of Central Yakutia, we may draw the following conclusions:

1. low-head earth dams should be planned to prevent filtration (frozen-type);

2. the extreme temperature state of small dams is reached in the first 7-10 years of operation, so the heat calculation for storage dams may be restricted to determining their extreme state; in doing this the cooling effect of the banks of the river valley should be taken into account where necessary, as should the warming effect of heat from the earth's interior;

3. small dams of thawed ground which are up to 5-6 meters high freeze completely in the first 1-2 years after construction (if there is no subchannel talik);

4. a filtering dam 4.5 meters high, in the absence of a subchannel talik and with a head of two meters (water 3.5 meters deep in the upper pool), was found to be completely frozen at the moment of investigation three years later; this was under natural conditions with no special steps having been taken;

5. the thermal effect of temporary pools on the temperature regime of catchwork dams may be ignored.